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GB 1598098 A GB 1338553 A GB 0999494 A
EP 0389407 A1 WO 95/19533 A1 US 5255520 A

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(54) **Cooling apparatus**

(57) A cooling apparatus, which is suitable for use in a soft drinks machine or like liquid dispenser, and is compact and can cool the liquid fast enough to be acceptable in a demand-led arrangement and yet not cool it so much that it actually freezes, comprises a cooling system (11) that utilises a combination of a heat pump (17: typically a Peltier-effect device) coupled with a liquid/solid phase-change material (15) operating in the required temperature range (which will usually be from just above 0°C to around +5°C). A temperature-sensitive switching device, such as a thermistor (19) is thermally coupled to the liquid/solid phase-change material (15) and operatively linked to the heat pump (17) so as effectively to control the pump on or off as required. In one embodiment a series of copper pipes act to transfer heat between the heat pump (17) and the phase change material (15). In another embodiment, a heat exhanger containing liquid to be dispensed, contacts the outside of a thermally-conductive cone-shaped former.

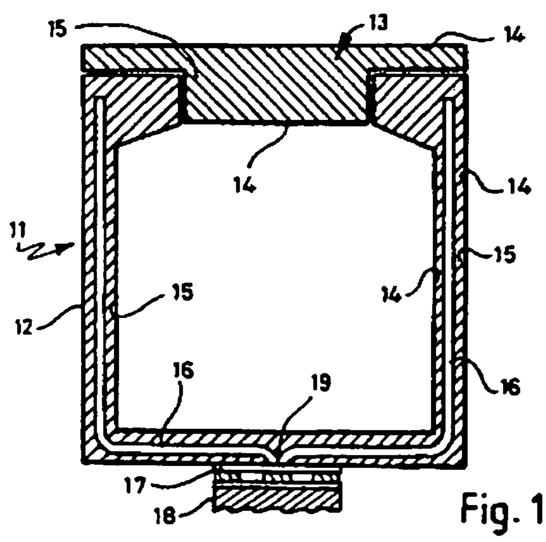

Fig. 1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

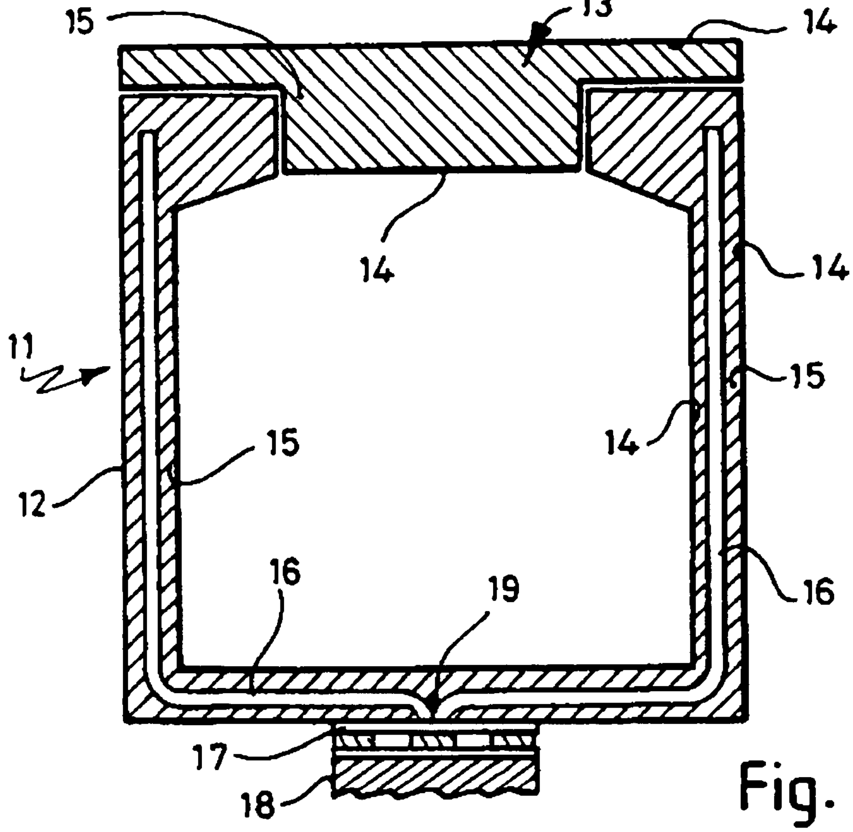
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Fig. 1

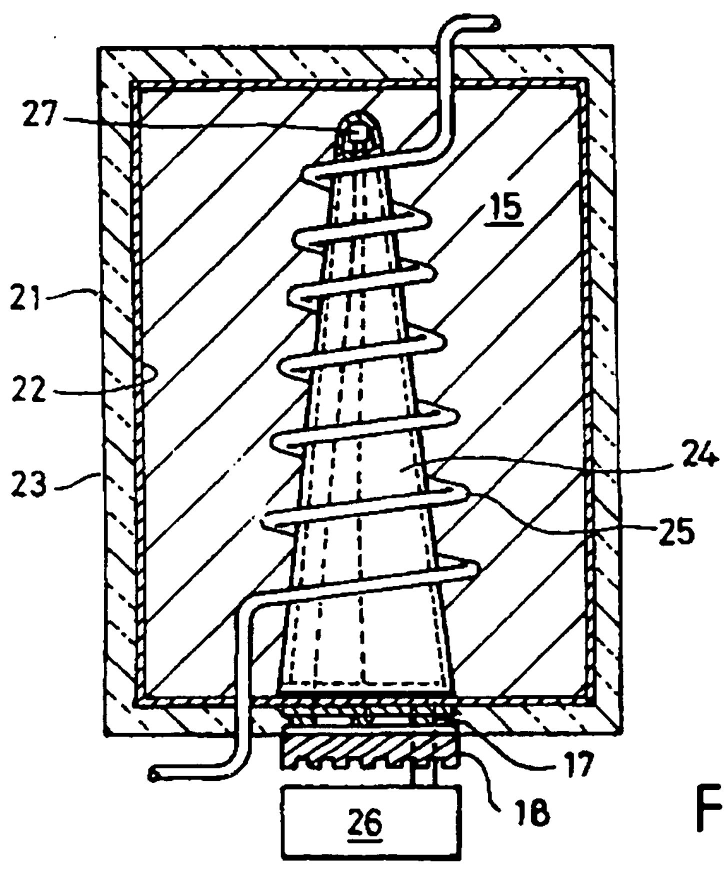
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Fig. 2

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Cooling apparatus

This invention relates to cooling apparatus, and concerns in particular apparatus for cooling liquids such as soft drinks.

There are many occasions when it is desirable to provide a material, and particularly a liquid, in a cooled state, typical examples being in the dispense of liquids such as water and other potable materials (possibly in a carbonated form) for drinking purposes. Some such liquids come in and are dispensed in cans - the various Colas are often of this type - but many (including drinks such as the Colas and the lemonades and tonic waters) are delivered, sometimes in metered amounts, from a large reservoir (and most commonly this is a reservoir of concentrate, outputting to a mixer unit where it is diluted with water, optionally made effervescent by passing in carbon dioxide under pressure, and then dispensed through a tap straight into the drinker's glass).

There are already available a large number of cooling units specifically for the purpose of cooling drinks like water, lemonade, cola, beer, lager or cider in draught form, but these are for the most part basically little more than conventional refrigerators (with toxic or environmentally-unfriendly refrigerant, such as a chlorofluorohydrocarbon or ammonia) that cool a large volume of water (or sometimes glycol) as a bulk coolant medium through which the liquid to be dispensed is then passed *via* a heat-transfer coil tube from which it is delivered on demand. To stop the bulk medium

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freezing the unit conventionally includes a suitably-positioned thermostat and an agitator that keeps the medium moving. However, to overcome the possibility of supercooling it is necessary to operate the cooling system at around -10°C, which obviously gives rise to a serious - and unacceptable - risk of a water-based product liquid freezing solid. This further complicates the design of the unit, and as a result of all these factors the conventional units are bulky (and heavy), expensive, and prone to spillage. There is a clear need for a smaller apparatus able to provide the same cooled liquid but without either the risk of freezing the product itself or the cost and sheer volume of the more conventional units. It is such an apparatus that the present invention proposes; more specifically, the invention will suggest a much smaller, neater cooling apparatus in which the primary liquid is cooled on demand without the problems of large volumes of coolant medium, icing up, and toxic materials.

There are, however, problems in having relatively small amounts of liquid cooled by conventional refrigeration technology (in which a vaporisable liquid is pumped through an orifice and caused to undergo adiabatic expansion in a heat-exchanger tube, thereby "sucking" heat from the environment surrounding the tube, before being compressed and pumped back *via* another heat-exchanger, where it gives up the acquired heat energy to the outside, round the circuit to the orifice). Firstly, the sheer mechanics of such a refrigeration system take up quite a lot of space, and secondly it is not easy to arrange that the liquid can be cooled fast enough to be acceptable in a demand-led arrangement and yet not cooled so much that it actually freezes. The invention puts forward a solution to these problems. Thus, firstly it suggests the use of a

cooling system that utilises a combination of a heat pump (typically a Peltier-effect device) with an output matched to the thermal characteristics and desired throughput rate of the liquid to be dispensed coupled with - and directly cooling - an ambient medium in the form of a liquid/solid phase-change material operating in the required temperature range (which will usually be from just above 0°C to around +5°C (this naturally considerably reduces the possibility of over-cooling the liquid). Secondly, the invention suggests a temperature-sensitive switching device, such as a thermistor, thermally coupled to the liquid/solid phase-change material and operatively linked to the heat pump so as to switch the pump in and out as required.

More specifically, the invention proposes firstly, as a system for cooling any material, liquid or solid, a cooling apparatus including a cooling unit that comprises a body of liquid/solid phase-change material that undergoes its phase change in a temperature range relevant to the material to be cooled, a heat-transfer interlayer contacting the phase-change material, and a heat pump connected to the interlayer and controlled by a thermally-sensitive switch. More specifically still, this first cooling apparatus comprises a thermally-insulated container (for holding the material to be cooled) the walls of which are hollow and filled with the phase-change material, with the interlayer within and surrounded by the phase-change material, with a heat pump mounted on the container and in contact with the interlayer and controlled by a thermally-sensitive switch device.

Secondly, the invention suggests a rather more complex cooling apparatus designed particularly for cooling liquid materials, this being apparatus in which

the liquid to be cooled is pumped through a heat-exchanger pipe coiled around a hollow conductive former and surrounded by liquid/solid phase-change material, the whole being positioned within a thermally-insulated container with walls of a thermally-conductive material, one end of the conductive former being mounted in thermal contact with the container, and the coil pipe passing into and then out of the container, and there being a heat pump secured in thermal contact externally of the container adjacent the mounted-conductive-former end and a thermally-sensitive switch device mounted internally of the conductive former at the other end and operatively linked to the heat pump through the container wall.

In one aspect, therefore, invention provides cooling apparatus comprising :

a body of liquid/solid phase-change material that undergoes its phase change in a temperature range near to but above 0°C and relevant to the material to be cooled, which body is shaped to hold that material;

a thermally-conductive interlayer disposed on or in the phase-change material, in thermal contact therewith;

a heat pump mounted in operative thermal contact with the interlayer; and

a thermally-sensitive switch device mounted in thermal contact with the interlayer and operatively linked to the heat pump.

More specifically, this first aspect of the invention is apparatus comprising:

a hollow-walled thermally-insulated container suitable for holding the material to be cooled, the walls of which container are filled with a phase-change

material that undergoes its phase change in a temperature range near to but above 0°C and relevant to the material to be cooled;

a thermally-conductive interlayer disposed within the walls and surrounded by the phase-change material;

a heat pump mounted externally of the container on and in operative thermal contact through the container wall with the interlayer; and

a thermally-sensitive switch device mounted in thermal contact with the interlayer and operatively linked to the heat pump.

In a second aspect this invention provides apparatus for cooling liquids, the apparatus comprising:

a walled container;

an elongate conductive former within that container, the former having one end mounted in thermal contact to a container wall and extending into the volume defined by the container;

a heat-exchange pipe coiled around the former, through which pipe the liquid to be cooled can be pumped, the pipe having its input and output ends passing through the container walls, and so outside the container;

a liquid/solid phase-change material filling the space within the container surrounding the coil and its former, the material being one that undergoes its phase change in a temperature range near to but above 0°C and relevant to the liquid to be cooled, which phase-change material forms the required body of such material, and which is shaped by the coiled heat-exchange pipe so as to hold the material to be cooled as that material is passed therethrough;

a heat pump mounted externally of the container on and in operative thermal contact with the container wall and adjacent that end of the coil former secured to a container wall; and

a thermally-sensitive switch device mounted on the coil former at the wall-distant end, which device is operatively linked through the container wall to the heat pump.

The invention provides apparatus for cooling materials, and in its simpler and broader form may cool any object that the phase-change material can be shaped around, whether intrinsically solid (such as a laboratory sample) or temporarily solid (such as a phial or ampoule of vaccine) or liquid (such as blood or plasma, or a potable liquid). In its second, coiled-pipe form the apparatus is designed for cooling liquids, especially drinks as typified by still or fizzy (carbonated) waters or soft drinks.

The preferred apparatus of the invention includes a walled container in or on the walls of which are mounted/retained the various other components. The walls are most conveniently of a thermally-conductive material (such as copper), to assist in heat-transfer between the heat pump and the phase-change material, but to prevent an undesirable gain of heat from the ambient surroundings the container is very preferably thermally-insulated externally thereof. This thermal insulation is best provided by a jacket of the type known as a "super-insulating" jacket; the most preferred variety of super-insulating jacket is that provided by a conventional vacuum flask form (as known for many years generally by the terms "Dewar" or "Thermos" flask), but more recently there have come onto the market a number

of foamed resin materials which can give nearly as good an insulating effect as a vacuum flask, and these can be used with much less risk of breakage.

Within the liquid-cooling version's apparatus' container is an inwardly-projecting elongate thermally-conductive former mounted at one end on and in thermal contact with a container wall and extending into the volume defined by the container. The conductive former, whose primary purpose is to aid the spread of the cooling effect of the heat pump evenly throughout the phase change material, and so help avoid substantial temperature gradients within the container, is conveniently hollow (with the thermal switch mounted inside it). It may be of any appropriate elongate shape - for example, a simple circular-section parallel-sided tube, or a cone. It may even itself be twisted/coiled, so as to maximise its heat-transfer surface area within the container.

Coiled - conveniently helically - around the former is a heat-exchange pipe through which the liquid to be cooled can be pumped. The pipe, which has its input and output end portions passing through the container walls, and so lying outside the container, may be of any suitable thermally-conductive material; for liquid foodstuffs, such as, say, soft drinks like lemonade or mineral water, this should most preferably be a food-grade stainless steel.

Although for the most part only a single such coil would be necessary, it might on occasion be desirable to have two separate coils, for two separate liquids - in a soft drink dispenser, for example, there might be one coil for the water forming the bulk of the drink, and another for the syrup containing the essence of the drink. And if there were several different such syrups,

for several different drinks, then there would be a corresponding number of syrup coils.

The heat-exchanger pipe may have associated with it some form of valving, or flow-restriction device, so as to enable there to be exercised some control over the rate at which the liquid being cooled actually passes therethrough, and thus to allow a concomitant control of the time for which the liquid is chilled.

Filling either the hollow walls of the container (in the simpler apparatus) or, as appropriate, the space within the container surrounding the coil and its former (in the liquid cooling apparatus) is a liquid/solid phase-change material. This material is naturally one that undergoes its phase change in a temperature range relevant to the liquid to be cooled - that is, a range of from +0.5° to +5.5°C (for most potable liquids). Suitable such materials are those made by Exxon and sold by Phase Change Laboratories Inc., of San Diego, California, USA under the Tradename NORPAR (RTM) 15 (believed to be paraffins - that is, long chain alkanes - mixed with micropore silica to cause them to provide effective heat-transfer properties in a gel-like form).

The simpler form of the cooling apparatus has a thermally-conductive interlayer disposed on or in the phase-change material, in thermal contact therewith (the liquid-cooling version uses the container walls for this purpose). This interlayer might be just that - a layer, such as a sheet or mesh of material - but is more conveniently a number of rods or pipes disposed uniformly throughout the phase-change material. The interlayer is, of course, made of a substance that is a good thermal conductor, such as copper.

Mounted outside the container, on and in operative thermal contact with the interlayer or (in the liquid-cooling version) that wall on which the coil former is secured, is the heat pump (together, of course, both with an associated heat sink, which may if required be of the forced-air or fan-cooled type, with heat-recovery capabilities, and also with the means by which the pump can be operatively connected to an appropriate power supply). There are various sorts of small heat pump that could be of use in this situation, but the most preferred is one using the Peltier effect - that is, one in which an electric current is passed through connected conductors of different materials, causing the junction of the two to absorb heat from its surroundings (and so become cool). Heat pumps of this type are already well known in several fields, and these days it is usual for them to take the form of a semiconductor device (rather than two joined dissimilar-metal wires). Typical examples of such semiconductor heat pumps are those available from Marlow Industries Inc., of Dallas, Texas, USA.

It will be understood that the heat pump will be so chosen that its capacity - its ability to provide an acceptable degree of cooling - will be matched to the thermal characteristics (specific heat, latent heat of cooling, and mass throughput) of the solid or liquid the apparatus is being used to cool. It will also be understood that for safety reasons the power supply connections to the heat pump will most preferably be by way of a thermal fuse.

In the liquid-cooling version the heat pump is mounted externally of the container on and in operative thermal contact with the container wall and adjacent the wall-mounted end of the coil former. There is little to

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say about this, except to point out that the closer the pump is mounted to the coil former end the more easily it can draw heat away therefrom.

Operatively associated with the heat pump is a thermally-sensitive switch device (in the liquid-cooling version this switch is mounted on - and, with a hollow former, preferably internally of - the wall-distant end of the coil former, and is operatively linked through the container wall to the heat pump). The device is most conveniently a thermistor - typical examples of such are those available from Fraser-Milne, of Cambridge, England, under the Tradename 35 Hyster 2 - connected by wires into the power cables to the pump (either in such a way that it can switch the power to the pump on or off as required, or *via* some sort of variable-resistor load, or choke, allowing it to control the the effective on/off state of the heat pump more flexibly).

The cooling apparatus of the invention may be used in a number of ways for a number of purposes, as has already been intimated hereinbefore. Moreover, two such examples - both the simpler version and the liquid-cooling version - may be used together (thus, one to cool and then store a liquid prior to it being delivered, and further cooled, through the other on demand). Furthermore, if, in the liquid-cooling version, the main container is of sufficient size, then it may include within it - surrounded and cooled by the phase-change material - a secondary container acting as a preliminary-cooling reservoir for liquid subsequently to be delivered to, and from, the main cooling coils. Such a secondary container might be used to hold one or other of the ingredients of a multi-component drink -

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for example, either the syrup or the water of a soft drink, such as lemonade, to be made up on demand. Another possible use for such a secondary container is as a carbonation station, at which carbon dioxide is forced under pressure into the liquid, so resulting in a "sparkling", or fizzy, drink. Yet another use might be as a filtration and purification station, at which the main bulk liquid - tap water, say - could be treated to remove impurities therein (conventional by filtration through an appropriate ion-exchange medium).

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Two embodiments of the invention are now described, though by way of illustration only, with reference to the accompanying Drawings in which:

<u>Figure 1</u> shows, in part section, a side view of one embodiment of cooling apparatus of the invention; and

<u>Figure 2</u> shows, also in part section, a side view of another embodiment of cooling apparatus of the invention.

The embodiment shown in Figure 1 is the simpler cooling apparatus of the invention, useable to cool almost any object, whether solid or liquid (but in a jar or other container). The apparatus comprises a container (generally 11) having a main body (12) with a lid (13) each of which is hollow and has hollow walls (as 14) made of a thermally-insulating material and filled with a liquid/solid phase-change material (15). Disposed within the body of phase-change material 15 is a series of copper pipes (as 16: only two are shown) to act as a heat transfer medium, and operatively mounted under and outside the container body 12 is a heat pump (17: with thermal fuse, not clearly shown) with its associated heat sink (18) (in this Figure the power connections to the heat pump are not shown). A thermistor (19) is mounted on the heat-transfer copper pipes 16 immediately above the heat pump 17 (its connections into the power supply are not shown).

It will be appreciated that, as the heat pump operates, it "sucks" heat out of the copper pipes 16,

which in turn conduct heat away from the phase-change material 15. And this, in turn, removes heat from the space within the container body 12, cooling whatever is stored therein.

The embodiment of Figure 2 is for the cooling of liquids. It has a closed body (21) that is made of a thermally-conductive material (22) with an outer super-thermally-insulative covering (23). The volume defined by the body 21 is filled with the liquid/solid phase-change material (15).

Within the body 21, and mounted on, and upstanding from, the bottom (as viewed) wall, with which its base is in good thermal contact, is a cone-shaped coil-former (24) made of a good thermally-conductive material. Around this cone is helically wound a heat-exchange coil (25) through which is, in use, passed the liquid to be cooled.

On the outside bottom (as viewed) of the container body 21 is a heat pump 17 (with its associated heat sink 18 and thermal fuse [not shown]); this is powered by a (12V DC) power source (26) controlled by a thermistor (27) mounted inside the top (as viewed) end of the cone 24).

It will be understood that, in operation, the liquid to be cooled is pumped through the coil 25, the heat energy therein being removed through the coil into the surrounding phase-change material 15, which itself is cooled by heat transfer both through the walls 22 of the container body 21 and through the cone 24 as driven by the heat pump 17 (suitably controlled by the thermistor 27).

CLAIMS

1. Cooling apparatus comprising :

a body of liquid/solid phase-change material that undergoes its phase change in a temperature range near to but above 0°C and relevant to the material to be cooled, which body is shaped to hold that material;

a thermally-conductive interlayer disposed on or in the phase-change material, in thermal contact therewith;

a heat pump mounted in operative thermal contact with the interlayer; and

a thermally-sensitive switch device mounted in thermal contact with the interlayer and operatively linked to the heat pump.

2. Apparatus as claimed in Claim 1, which is apparatus comprising:

a hollow-walled thermally-insulated container suitable for holding the material to be cooled, the walls of which container are filled with a phase-change material that undergoes its phase change in a temperature range near to but above 0°C and relevant to the material to be cooled;

a thermally-conductive interlayer disposed within the walls and surrounded by the phase-change material;

a heat pump mounted externally of the container on and in operative thermal contact through the container wall with the interlayer; and

a thermally-sensitive switch device mounted in thermal contact with the interlayer and operatively linked to the heat pump.

3. Apparatus as claimed in Claim 1, which is apparatus comprising:

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a walled container;

an elongate conductive former within that container, the former having one end mounted in thermal contact to a container wall and extending into the volume defined by the container;

a heat-exchange pipe coiled around the former, through which pipe the liquid to be cooled can be pumped, the pipe having its input and output ends passing through the container walls, and so outside the container;

a liquid/solid phase-change material filling the space within the container surrounding the coil and its former, the material being one that undergoes its phase change in a temperature range near to but above 0°C and relevant to the liquid to be cooled, which phase-change material forms the required body of such material, and which is shaped by the coiled heat-exchange pipe so as to hold the material to be cooled as that material is passed therethrough;

a heat pump mounted externally of the container on and in operative thermal contact with the container wall and adjacent that end of the coil former secured to a container wall; and

a thermally-sensitive switch device mounted on the coil former at the wall-distant end, which device is operatively linked through the container wall to the heat pump.

4. Apparatus as claimed in any of the preceding Claims which includes a walled container in or on the walls of which are mounted/retained the various other components, wherein the walls are of a thermally-conductive material, to assist in heat-transfer between the heat pump and the phase-change material, and wherein, to prevent an undesirable gain of heat from the ambient

surroundings, the container is thermally-insulated externally thereof.

5. Apparatus as claimed in any of the preceding Claims which is primarily for cooling liquids and includes within the container the former around which is coiled a heat-exchange pipe through which the liquid to be cooled can be pumped, wherein the former is hollow, and the thermal switch is mounted inside it.

6. Apparatus as claimed in any of the preceding Claims which is primarily for cooling liquids and includes within the container the former around which is coiled a heat-exchanger pipe through which the liquid to be cooled can be pumped, wherein the heat-exchanger pipe has associated with it a valving, or flow-restriction device.

7. Apparatus as claimed in any of the preceding Claims, wherein the liquid/solid phase-change material is one that undergoes its phase change in a temperature range of from +0.5° to +5.5°C.

8. Apparatus as claimed in any of the preceding Claims which is the simpler version of a hollow-walled thermally-insulated container the walls of which are filled with a phase-change material in which is disposed a thermally-conductive interlayer, wherein the interlayer takes the form of a number of thermally-conductive rods or pipes disposed uniformly throughout the phase-change material.

9. Apparatus as claimed in any of the preceding Claims, wherein the heat pump is one using the Peltier effect.

10. Apparatus as claimed in any of the preceding Claims, wherein the thermally-sensitive switch device operatively associated with the heat pump is a

thermistor suitably connected by wires into the power cables to the pump.

11. Cooling apparatus as claimed in any of the preceding Claims and substantially as described hereinbefore.

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The Patent Office

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Application No:	GB 9616635.0	**Examiner:**	Mick Monk
Claims searched:	All	**Date of search:**	29 October 1996

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): F4H (HG9, HG13, H2K, H3, H7); H1K (KTQ)

Int Cl (Ed.6): F25B (21/02); F25D (3/00, 11/00)

Other: ONLINE DATABASE: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	GB 1598098	(BENTLER-WERKE) Example of a double-walled container, the space between the walls housing a eutectic solution.	1
A	GB 1338553	(ELECTRICITY COUNCIL) See eg Fig.2.	1
A	GB 999494	(ELFVING) Example of a thermoelectric refrigerated device.	1,2
X	EP 0389407 A1	(UNITED TECHNOLOGIES) See eg Fig.4.	1 at least
X	WO 95/19533 A1	(MARLOW) See eg Figs. 4a-4d & 6a-6d.	1,2,4,7,9 at least
X	US 5255520	(REFIR TECHNOLOGIES) Consider whole document	1 at least

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

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